CLAIMS

What is claimed is:

1. A vibroacoustic emulator for emulating vibroacoustics of a hard disk drive, comprising:

a housing having:

a base side defining in-plane directions parallel to the base side and an out-of-plane direction perpendicular to the in-plane directions;

a cover side substantially parallel to the base side;

the housing having dimensions and mechanical attachment fixtures that replicate those of the hard disk drive; and

a vibroacoustic generator coupled to the housing.

2. The vibroacoustic emulator of claim 1 wherein the vibroacoustic generator comprises:

a first speaker coupled to the cover side of the housing; and

a second speaker coupled to the base side of the housing.

3. The vibroacoustic emulator of claim 2, further comprising:

a first speaker signal generator for providing input signals to the first speaker; and

a second speaker signal generator for providing input signals to the second speaker.

4. The vibroacoustic emulator of claim 2, wherein the first and second speakers are each less than approximately 2 mm thick and each has a frequency response as low as 100 Hz.

5. The vibroacoustic emulator of claim 1 wherein the vibroacoustic generator comprises:

an out-of-plane vibration source coupled to the housing.

6. The vibroacoustic emulator of claim 5, further comprising:

an out-of-plane signal generator for providing input signals to the out-of-plane vibration source.

7. The vibroacoustic emulator of claim 5, wherein the out-of-plane vibration source comprises:

a wire coil suspended in a plane substantially parallel to the base side of the housing;

a magnetic field producer for producing a magnetic field parallel to the plane of the wire coil; and

an out-of-plane vibration signal generator for providing input signals to the wire coil.

8. The vibroacoustic emulator of claim 7, wherein the magnetic field producer comprises NdFeB magnets joined by a yoke.

9. The vibroacoustic emulator of claim 5, wherein the out-of-plane vibration source comprises:

a support element coupled to the housing;

a piezoelectric stack having a proximal end and a distal end, the piezoelectric stack being coupled at its proximal end to the support element; and

an end mass coupled to the distal end of the piezoelectric stack.

10. The vibroacoustic emulator of claim 1 wherein the vibroacoustic generator comprises:

an in-plane vibration source coupled to the housing.

11. The vibroacoustic emulator of claim 10, further comprising:

an in-plane signal generator for providing input signals to the in-plane vibration source.

12. The vibroacoustic emulator of claim 11, wherein:

the in-plane vibration source comprises a plurality of in-plane actuators arranged substantially in a plane; and

the in-plane signal generator is organized to provide phased input signals to the in-plane actuators to synthesize a rotating in-plane force.

13. The vibroacoustic emulator of claim 12 wherein each in-plane actuator comprises piezoelectric stacks attached at a distal end to an end mass and at a proximal end to a common mount.

14. The vibroacoustic emulator of claim 1 wherein the housing is disposed in an electronic device where the hard-disk drive would be positioned.

15. A vibroacoustic emulator, comprising:

a housing; and

a means for producing controlled variable vibroacoustic signals that simulate those of an electronic-device component, wherein the means is coupled to the housing.

16. The vibroacoustic emulator of claim 15 wherein the electronic-device component is a hard disk drive.

17. The vibroacoustic emulator of claim 16, wherein the housing is disposed in an electronic device where a hard disk drive would be positioned, and wherein the housing has dimensions and mechanical attachment fixtures that replicate those of the hard disk drive being emulated.

18. The vibroacoustic emulator of claim 15 wherein the means for producing controlled variable vibroacoustic signals comprises:

a first speaker coupled to a first side of the housing; and

a first speaker signal generator for providing input signals for driving the first speaker.

19. The vibroacoustic emulator of claim 18 wherein the means for producing controlled variable vibroacoustic signals further comprises:

a second speaker coupled to a second side of the housing, the first and second sides of the housing being different; and

a second speaker signal generator for providing input signals for driving the second speaker.

20. The vibroacoustic emulator of claim 19, wherein the first and second signal generators share the same hardware.

21. The vibroacoustic emulator of claim 15 wherein the means for producing controlled variable vibroacoustic signals comprises:

a plurality of in-plane actuators arranged substantially in a plane about a common mount; and a rotational signal generator for providing input signals for driving the plurality of in-plane actuators such that a rotating force substantially in the plane of the in-plane actuators is produced.

22. The vibroacoustic emulator of claim 21 wherein the means for producing controlled variable vibroacoustic signals further comprises:

an out-of-plane actuator for producing vibrations perpendicular to the plane of the in-plane actuators; and

an out-of-plane signal generator for providing input signals for driving the out-of-plane actuator.

23. The vibroacoustic emulator of claim 22 wherein the rotational signal generator and the out-of-plane signal generator share the same hardware.

24. The vibroacoustic emulator of claim 22 wherein the means for producing controlled variable vibroacoustic signals further comprises:

a first speaker coupled to a first side of the housing; and

a first speaker signal generator for providing input signals for driving the first speaker.

25. The vibroacoustic emulator of claim 24 wherein the first speaker signal generator and the rotational signal generator share the same hardware.

26. The vibroacoustic emulator of claim 24 wherein the first speaker signal generator and the in-plane signal generator share the same hardware.

27. A method for emulating hard-disk-drive vibroacoustics comprising:

generating independently controlled acoustic waves initially traveling perpendicular to a base side of a housing;

generating independently controlled vibratory motions in directions perpendicular to the base side of the housing;

generating independently controlled vibratory motions in directions parallel to the base side of the housing.

28. The method for emulating hard-disk-drive vibroacoustics, according to claim 27, wherein the independently controlled vibratory motions in directions parallel to the base side of the housing synthesize a rotating force.

29. The method for emulating hard-disk-drive vibroacoustics, according to claim 27, wherein the housing is disposed in an electronic device where a hard disk drive would be positioned.

30. The method for emulating hard-disk-drive vibroacoustics, according to claim 27, further comprising:

measuring the system response to the independently controlled acoustic waves, vibratory motions in directions perpendicular to the base side of the housing, and vibratory motions in directions parallel to the base side of the housing.

31. A method for characterizing electronic-device vibroacoustics comprising:

substituting a vibroacoustic emulator for a vibroacoustic-producing component in an electronic device;

generating controlled vibroacoustics with the vibroacoustic emulator;

measuring a quantity related to system vibroacoustics.

32. The method for characterizing electronic-device vibroacoustics, according to claim 31, further comprising:

determining a system transfer function that relates the controlled vibroacoustics of the vibroacoustic emulator to the system vibroacoustics.

33. The method for characterizing electronic-device vibroacoustics, according to claim 31, wherein:

the vibroacoustic-producing component is a hard-disk drive; and

the controlled vibroacoustics generated with the vibroacoustic emulator comprises:

a rotating in-plane force.

34. The method for characterizing electronic-device vibroacoustics, according to claim 31, wherein:

the vibroacoustic-producing component is a hard-disk drive; and

the controlled vibroacoustics generated with the vibroacoustic emulator comprises:

a vibratory out-of-plane force.

35. The method for characterizing electronic-device vibroacoustics, according to claim 31, wherein the controlled vibroacoustics is varied to determine noise resonances of the electronic device.

36. The method for characterizing electronic-device vibroacoustics, according to claim 31, wherein the controlled vibroacoustics is varied to determine parameters of the controlled vibroacoustics that produce maximal reductions to the end-user perceived noise.